What shape is it?

Overview: Determine the shape of an unseen object by bouncing a ball off the object.

Grades: 4-8 (See links to national science and math standards at the end.)

Time: 45 minutes to an hour

Background: Scientists make observations about the natural world. Some things can be directly observed, others can not. For things that we can not directly observe, we can use indirect observation – which studies the consequences of an action or process. For example, we cannot see the Earth's magnetic field, but we detect it by its effect on a compass.

We can only see things if they give off light – like a star – or light bounces off of them – like the moon and most other things. So we see things because light bounces off objects back towards us. We can use other senses to gather information about things we cannot see, such as hearing. For example, sonar involves bouncing sound waves off an object and observing the reflected wave. This technique is also used in echo-location. Dolphins and bats use echo-location to detect the location and shape of an object, by sending out a sound wave and observing how the reflected sound wave comes back to them.

In the lesson "Where will it go?" we predict where a ball will go after it bounces off a fixed object. We use the shape of object and how it hits the object (the angle it strikes the surface at) to figure out where it will go. So you can observe how a ball bounces off an object to figure its shape.

We can use the light that bounces off of objects to study their properties. However, if something is too small for light to bounce off of it – then we need to use other methods. Particle physicists study things that are too small to use light, such as atoms (0.0000000001 meters wide) and the building block of atoms. In 1909 Earnest Rutherford directed a beam of helium nuclei (2 protons and 2 neutrons--much smaller than an atom) at a very thin foil of gold. At this time scientists did not know what made an atom. Some of the nuclei did not pass straight through because they bounced off of something and were reflected back. They had made an important discovery about the structure of an atom – they had discovered the nucleus of an atom. They figured out the size of the nucleus by bouncing more particles off of it and observing the paths they took. Physicists today study particles that are much smaller an atom, known as subatomic particles (e.g. electrons, protons, neutrons). They study them by making them go very fast and smashing them together to create even smaller bits and watch how they bounce off of each other.

Objective: Bounce balls off of hidden objects to determine their shape.

Materials: Each pair of students needs

- Several shapes that are flat on the top and bottom
  (These shapes could be cut from ¾ in plywood. They just need to be thicker than the balls. A round cake pan or large cookie cutters could be used. They should be weighted down or taped down so that they don't move when the ball is bounced off of them.)
- A concealing large flat object (e.g. cardboard, foamboard, masonite, white board, plywood)
  (It should be large enough and low enough so that the object cannot be seen, but high enough so that the balls will not get stuck.)
- Small rubber balls (e.g. from a Jacks set) or large marbles (1/2 inch diameter)
- Large piece of paper
- Pencil
- Ruler

Procedure:

1. Prepare hidden shapes fixed to concealer boards ahead of time for students.

2. Demonstrate how balls bounce off of objects using a shape that is visible. Have the students think about how the ball would move differently if the object was a different shape.

3. Give students a hidden object (prepared in Step 1), a rubber ball and a ruler.

4. Have the students place the hidden objects on the middle of their piece of paper.

5. Have the students select a starting point and mark it on the paper as trial 1:in. Have them roll the rubber ball from that point and bounce it off the object (students can roll the ball along the edge of the ruler to help control the path of the ball).

6. Observe the outgoing path of the rubber ball, trace it on the paper and label it as trial 1:out.

7. Change the starting point and repeat experiment (Steps 5 and 6). Be sure to label each trial in and out.

8. When students feel they have collected enough data to predict the shape, have them draw their predicted shape and check result. If they have not accurately predicted the shape, then they can continue with more trials.

9. Repeat the experiment with a new shape (given time restraints).

Results and Discussion:

How close was your predicted shape to the actual shape?
Could you have predicted the shape with fewer trials?
What would you change about your experiment?
Bouncing balls off of all sides of the object will tell you if it is symmetrical.
Smaller balls may give more details of smaller features in the shape.
Are some shapes harder or easier than others?

Follow up activities:

a. Use the *Where will it go?* lesson plan for a review of how objects bounce off of a fixed object.
b. Play the *Quarked Catcher* game at the Quarked website - www.quarked.org.

c. Play the *Shape Sleuth* game at the Quarked website - www.quarked.org.
d. Lesson plan *Invisible Investigations* explores how to find out about something you can't see.
e. To learn more about particle physics, check out the www.fnal.gov site.

NATIONAL STANDARDS

This lesson plan addresses the following national standards in science and math:

Science

Standard A – Science as Inquiry
Students should develop abilities necessary to do scientific inquiry and an understanding about scientific inquiry.

Standard B-Physical Science
Students should develop an understanding of the properties of objects and motions and forces

Standard G-History and Nature of Science
Students should develop understanding of the nature of science and the history of science

Math

Understand patterns, relations, and functions
- Represent and analyze patterns and functions, using words, tables, and graphs.

Geometry Standard
- Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships
- Identify, compare, and analyze attributes of two- and three-dimensional shapes and develop vocabulary to describe the attributes;

Measurement Standard
- Understand measurable attributes of objects and the units, systems, and processes of measurement
- Understand such attributes as length, area, weight, volume, and size of angle and select the appropriate type of unit for measuring each attribute;

Data Analysis and Probability Standard
- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
- Design investigations to address a question and consider how data-collection methods affect the nature of the data set;
- Collect data using observations, surveys, and experiments;